

***Pfiesteria*-Related Educational Products and Information Resources Available to the Public, Health Officials, and Researchers**

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Public and political concerns about *Pfiesteria* from 1997 to the present vastly exceed the attention given to other harmful algal bloom (HAB) issues in the United States. To some extent, the intense focus on *Pfiesteria* has served to increase attention on HABs in general. Given the strong and continuing public, political, and research interests in *Pfiesteria piscicida* Steidinger & Burkholder and related organisms, there is a clear need for information and resources of many different types. This article provides information on *Pfiesteria*-related educational products and information resources available to the general public, health officials, and researchers. These resources are compiled into five categories: reports; website resources; state outreach and communication programs; fact sheets; and training manuals and documentaries. Over the last few years there has been rapid expansion in the amount of *Pfiesteria*-related information available, particularly on the Internet, and it is scattered among many different sources. **Key words:** communication and outreach, dinoflagellate, fish kill, HAB, harmful algal bloom, *Pfiesteria*, *Pfiesteria*-like organisms, *Pfiesteria* Interagency Coordination Workgroup, PICWG, PLO, state monitoring, toxin, website. — *Environ Health Perspect* 109(suppl 5):695–698 (2001).

<http://ehpnet1.niehs.nih.gov/docs/2001/suppl-5/695-698kleindinst/abstract.html>

Although the first fish kill attributed to *Pfiesteria piscicida* Steidinger & Burkholder took place in May 1991 in the North Carolina Ablemarle–Pamlico Estuarine System (1), widespread public awareness and concern about *P. piscicida* and related organisms did not begin until 1997. During that summer, a fish kill occurred in the Pocomoke River near Shelton, Maryland, resulting in the closing of a portion of the river for fishing and other recreational activities. As other Maryland rivers were subsequently closed because of additional fish kills, significant media attention was directed at *Pfiesteria*. Several newspaper articles were published, some of which sensationalized the events, referring to *Pfiesteria* as the “cell from hell” or other similar names, fueling the so-called *Pfiesteria* hysteria.

In retrospect it is clear that public and political concerns about *Pfiesteria* from 1997 to the present vastly exceed the attention given to other harmful algal bloom (HAB) issues in the United States. To some extent the intense focus on *Pfiesteria* has increased attention on HABs in general. Given the strong and continuing public, political, and research interests in *P. piscicida* and related organisms, there is a clear need for information and resources of many different types.

This article provides information on the *Pfiesteria*-related educational products and information resources available to the general public, health officials, and researchers. These are compiled into five categories: reports; website resources; state outreach and communication programs; fact sheets; and training manuals and documentaries. This compilation does not include peer-reviewed scientific publications on *Pfiesteria*, of which there are

many. One comprehensive listing of such bibliographic information is found at <http://www.nalusda.gov/wqic/Bibliographies/eb9704.html>.

There has been considerable confusion about the use of the term *Pfiesteria*, as there are two toxic species [*P. piscicida* and *Pfiesteria shumwayae* Glasgow & Burkholder (2)] and a number of closely related organisms with some similar characteristics (e.g., *Cryptoperidiniopsis*). This group of organisms is sometimes termed “*Pfiesteria*-like organisms (PLOs),” but for convenience in this article, the term *Pfiesteria* will be used as a generic term for the group of related organisms.

Reports

“ECOHAB: The Ecology and Oceanography of Harmful Algal Blooms—A National Research Agenda”

This report was the first to include *Pfiesteria* research as part of the U.S. national HAB program (3). It includes a section on fish kills, describing the presence of the newly discovered *P. piscicida* organism in the Ablemarle–Pamlico system, North Carolina, and its association with fish kills and lesions. It also mentions that human exposure to aerosols from toxic cultures with live fish causes a variety of health problems, as described in Glasgow et al. (4). (The ECOHAB report is available online at <http://www.redtide.whoi.edu/hab/nationplan/ECOHAB/ECOHABhtml.html> or from The U.S. National Office on Marine Biotoxins and Harmful Algal Blooms/*Pfiesteria* Clearinghouse, Biology Dept., MS #32, Woods Hole Oceanographic Institution, Woods Hole, MA 02543 USA.)

“Cambridge Consensus” Report

In October 1997 the University of Maryland Center for Environmental Science convened a forum of scientists to provide advice on whether outbreaks of *Pfiesteria* may be reduced by controlling pollution sources. Their report is referred to as the “Cambridge Consensus” (5). The report lists 11 consensus findings regarding nutrient concentrations and trends, responses of PLOs to nutrients, and other factors. At the end of the report, the section “Clearing up Misconceptions” attempts to correct some erroneous reporting in news articles regarding *P. piscicida*, its life cycle, and human health effects. Nine critical environmental science needs were identified, including the development of more effective, more rapid means for positive identification of *Pfiesteria*-like dinoflagellates and their toxins, determination of the complete life histories of the species, and the role of nutrients. (The “Cambridge Consensus” report is available online at <http://www.mdsg.umd.edu/fish-health/pfiesteria/cambridge.html> or from the University of Maryland, Center for Environmental Science, Cambridge, MD 21613 USA.)

“National Harmful Algal Bloom Research and Monitoring Strategy: An Initial Focus on *Pfiesteria*, Fish Lesions, Fish Kills and Public Health”

This multiagency report was prepared in 1997 in response to a request from the White House to “develop and coordinate a long-term, national strategy for federally supported research and monitoring on problems associated with HABs, particularly *Pfiesteria* and *Pfiesteria*-like species” (6). This report modified eight objectives from “Marine Biotoxins and Harmful Algae: A National Plan” (7) to

This article is based on a presentation at the CDC National Conference on *Pfiesteria*: From Biology to Public Health held 18–20 October 2000 in Stone Mountain, Georgia, USA.

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We extend our thanks to the following people for their assistance in providing information for this article: K. Chytalo, A. Lewitus, and L. Spence. This research was supported by the following grants to D.M. Anderson: National Oceanic & Atmospheric Administration grant NA97OA0355 and U.S. Environmental Protection Agency grant X-82838701-0. This is contribution number 10367 of the Woods Hole Oceanographic Institution.

Received 8 January 2001; accepted 24 July 2001.

specifically address the *Pfiesteria* problem. One of these objectives was to “develop information, communication, educational, and public health materials and on-site training strategies” (6). The report recommended that information exchange across agencies, states, researchers, and the public be reviewed and facilitated. As a result of this recommendation, the National Clearinghouse for Information on *Pfiesteria* and *Pfiesteria*-like Organisms was established at the Woods Hole Oceanographic Institution, with Donald M. Anderson as director. Dr. Anderson was already directing the U.S. National Office for Marine Biotoxins and Harmful Algal Blooms, and the *Pfiesteria* Clearinghouse was incorporated into this framework. (The “National Harmful Algal Bloom Research and Monitoring Strategy” can be obtained online at <http://www.redtide.whoi.edu/hab/announcements/pfiesteria/pfiesteria-strategy.html> or from The U.S. National Office on Marine Biotoxins and Harmful Algal Blooms/*Pfiesteria* Clearinghouse, Biology Dept., MS #32, Woods Hole Oceanographic Institution, Woods Hole, MA 02543 USA.)

“Status of U.S. Harmful Algal Blooms: Progress towards a National Program”

This document was prepared in 1999 in response to a request by the U.S. House of Representatives Committee on Appropriations and provides a description of interagency efforts and progress toward a national HAB program (8). Information on HAB distribution in the United States is included, along with detailed maps portraying the expansion of events and the incidence of new problems (such as *Pfiesteria* and fish kills). Current research efforts are described, including the recently funded ECOHAB research program on *Pfiesteria* and PLOs in the Chesapeake Bay region. The report also explains efforts under

way in identification, purification, and assay development for *Pfiesteria* toxins. The ad hoc multiagency response to the *Pfiesteria* outbreaks and fish kills of 1997 is detailed here as well. (That response provided the initial funding to states for monitoring and assessment of water quality and fish health.) The report stresses the need for providing access to databases and information on HABs through federal, state, and public websites. (The status report may be obtained from the National Ocean Service, National Oceanic & Atmospheric Administration, 1315 East-West Highway, Silver Spring, MD 20910 USA.)

“*Pfiesteria* Monitoring Report”

This report summarizes the results of two workshops sponsored by the National Oceanic & Atmospheric Administration (NOAA): Workshop to Standardize *Pfiesteria* Monitoring Protocols, and Workshop to Standardize Fish Health Monitoring Protocols. The report includes: *a*) protocols for rapid-response assessments of toxic *Pfiesteria* outbreaks, *b*) standard parameters that should be measured when responding to events, and *c*) discussion of the integration of state and federal agency data sets into regional and national assessments. During the first workshop, a three-part interagency program was outlined to monitor for *Pfiesteria* and PLOs: *a*) rapid event response, *b*) comprehensive surveys and assessment, and *c*) routine monitoring.

Detailed information is provided on the procedures to follow when responding to a potential toxic *Pfiesteria* outbreak, including the safety precautions to be followed to protect human health. Sampling protocols are also well detailed for water quality, phytoplankton monitoring, and fish health monitoring. (This report is available online at http://www.redtide.whoi.edu/pfiesteria/NOAAworkshops/Pfiesteria_Monitoring_Rept.pdf.)

Website Resources

There are several internet websites providing information on or related to *Pfiesteria* and PLOs. A few are highlighted here, but there are many that could not be included because of space considerations. Table 1 lists internet addresses, website names, and key points for those websites that maintain current information on *Pfiesteria*.

North Carolina State University Aquatic Botany Laboratory Website

This website (<http://www.Pfiesteria.org/>) provides the following information:

- Background information on *Pfiesteria*. Information is provided on the history of *Pfiesteria* in North Carolina and its associations with fish kills. The website explains that many lab and field experiments support the view that human activities have slowly altered the environment so as to stimulate *Pfiesteria*'s fish-killing activity.
- Life cycles of *P. piscicida*. This diagram illustrates the complex life cycle of the organism, which includes at least 24 flagellated, amoeboid, and encysted stages or forms.
- Human health impacts. This section describes some of the symptoms experienced by individuals thought to have been exposed to toxin(s) through water contact or by inhaling toxic aerosols while working with toxic laboratory cultures of *Pfiesteria*.
- Ongoing research. This details the current research on *Pfiesteria* being conducted by J.M. Burkholder's laboratory: the nutritional ecology of *Pfiesteria*; identification of the substances in fish secreta/excreta that stimulate *Pfiesteria* spp. to become toxic; and the impacts of toxic *Pfiesteria* on fish reproduction, recruitment, and disease resistance.

Table 1. Websites providing information about *Pfiesteria*.

URL	Sponsored by/site name	Key elements
http://www.pfiesteria.org/	NC State University Aquatic Botany Laboratory	Background information on <i>Pfiesteria</i> ; life cycles of <i>Pfiesteria piscicida</i> ; human health impacts; ongoing research projects in J.M. Burkholder's laboratory; bibliography of articles on <i>Pfiesteria</i> ; abstracts of publications; image archive of <i>Pfiesteria</i> life stages
http://www.dnr.state.md.us/bay/pfiesteria	Maryland Department of Natural Resources	Monitoring results (current and past years); maps of bay/ <i>Pfiesteria</i> -affected areas in Maryland; summary of Maryland's <i>Pfiesteria</i> -related 2000 work plans
http://www.schs.state.nc.us/epi/hab/	NC Department of Health and Human Services/NC Harmful Algal Blooms (HAB) Program website	Information on the three components of state HAB program: education, surveillance, and research; quick facts on <i>Pfiesteria</i> ; frequently asked questions; health precautions; brochure: What is <i>Pfiesteria</i> ?; North Carolina fish kill events; North Carolina protocols for closing and reopening rivers affected by <i>Pfiesteria</i>
http://www.redtide.whoi.edu/pfiesteria	Woods Hole Oceanographic Institution/ <i>Pfiesteria</i> Technical Website	PLC Workgroup participant information; glossary of <i>Pfiesteria</i> -related terms; molecular information on PLOs; multiagency fact sheet on <i>P. piscicida</i> ; fish lesion fact sheet
http://www.redtide.whoi.edu/hab/	Woods Hole Oceanographic Institution/Harmful Algae page	HAB information including photographs of various HAB organisms, blooms, and impacts; human health problems and information on diagnosis and treatment; documents such as the National Plan and ECOHAB Science Plan. <i>Pfiesteria</i> bibliographies; information on PEAS; news articles
http://www.mdsg.umd.edu/fish-health/index.html	University of Maryland, Aquatic Pathology Center/Fish Health in the Chesapeake Bay	Information about <i>Pfiesteria</i> in the Chesapeake Bay; human health; fish diseases and lesions; seafood safety; ongoing research; contact listing to ask questions or report problems; chronology of <i>Pfiesteria</i> outbreaks and related issues in the Chesapeake Bay

NC, North Carolina.

- Bibliography of articles on *Pfiesteria*.
- Abstracts of publications.
- Image archive. Thumbnail images of all the known life stages of *Pfiesteria* are provided in this section. Clicking on the individual thumbnail brings up a larger image that can be printed or downloaded.

An additional resource to be added to this website, which should be very useful to researchers, is a pictorial atlas of *Pfiesteria*. The atlas comprises the many shapes and sizes of amoeboid, flagellated, and encysted stages of *Pfiesteria*. The atlas will be developed using light microscope photographs in conjunction with scanning electron microscope pictures (micrographs), enabling a presumptive identification of *Pfiesteria*-like dinoflagellates.

North Carolina Harmful Algal Blooms Program Website

This website, maintained by the North Carolina Department of Health and Human Services, is available at <http://www.schs.state.nc.us/epi/hab/> and provides information on the three basic components of the NC HAB program: education; surveillance; and research. The education component of the program provides a toll-free Care-Line number (1-800-662-7030) for individuals to obtain information on possible health risks from *Pfiesteria* exposure, report possible related health problems, report fish kills, and obtain information about waterway closings due to *Pfiesteria*. The HAB staff works in partnership with local health department staff and provides written information and training sessions. *Pfiesteria*-related information is also distributed to healthcare providers.

The surveillance component of the program is concerned with the adverse effects of *Pfiesteria* on human health. North Carolina, in cooperation with several other eastern coastal states and the national Centers for Disease Control and Prevention (CDC), is examining reports of medical conditions possibly linked to *Pfiesteria*, including those reported to their HAB hotline. The criteria for possible estuary-associated syndrome (PEAS) is also provided in this section.

The research component of the North Carolina program describes a separate public health study on the adverse human health effects of *Pfiesteria* that is being conducted in cooperation with the University of North Carolina School of Public Health. Researchers are studying 100 individuals with exposure to estuaries and potentially to *Pfiesteria* and comparing these results with those from 100 persons who have not been exposed to *Pfiesteria*. The two groups will be followed carefully over a period of time to see if there are significant differences in their health that might be attributable to exposure to estuaries where *Pfiesteria* has been identified.

Pfiesteria Technical Website

This website (<http://www.redtide.whoi.edu/pfiesteria>) is maintained by the National Clearinghouse for Information on *Pfiesteria* and *Pfiesteria*-like Organisms, located at the Woods Hole Oceanographic Institution. This nonpublic webpage was created for use by federal agencies, state agencies, and individuals involved in *Pfiesteria* monitoring, research, and management. This site is used to archive analytical and monitoring protocols, workshop reports, reference lists, fact sheets, etc. As standard methods for sampling, preservation, and analyses of *Pfiesteria* samples are produced by the states and federal agencies, the information is posted on the website and updated as necessary.

The Clearinghouse also maintains a restricted *Pfiesteria* listserver that provides information to numerous individuals in state agencies, participating federal agencies, and academic researchers. Information on recent or suspected outbreaks can be posted, and questions asked of all subscribers, ensuring the broadest possible assistance. As membership is restricted to those with a legitimate need for this information, requests to be added to the listserver should be directed to Judy Kleindinst (e-mail address: jkleindinst@whoi.edu), who will contact the relevant state representative to seek approval for the new member.

***Pfiesteria* Interagency Coordination (PIC) Workgroup participant information.** The workgroup comprises representatives from each state involved in *Pfiesteria* monitoring (Alabama, Delaware, Florida, Georgia, Maryland, Mississippi, North Carolina, New Jersey, New York, South Carolina, Texas, Virginia), several federal agencies [CDC, U.S. Environmental Protection Agency (U.S. EPA), U.S. Food and Drug Administration, NOAA, U.S. Geological Survey (USGS)], and academic researchers. This group participates in monthly conference calls to discuss new findings, update fact sheets, prepare for workshops and meetings, and share information and results from the states' monitoring activities.

One of the recent accomplishments of the group was the production of a draft glossary of *Pfiesteria*-related terms to provide consistent and scientifically correct definitions of words and phrases used to describe events and activities related to toxic *P. piscicida* and toxic *Pfiesteria*-like species (9). Some complex terms are defined at two levels. The first level provides a summary definition to improve the understanding of terms or phrases for a nontechnical reader. The second level provides additional or more detailed scientific information for the more technical reader. It is hoped that use of these terms will facilitate accurate and clear communication among scientists, managers, policy makers, the press, and the public.

Molecular information on PLOs. This section of the *Pfiesteria* Technical Website

provides up-to-date information on molecular research on PLOs, such as investigator, strain and culture numbers, source, sequence information, and the status of various molecular assays being developed for each species. As new information is provided by researchers, the website is updated.

Fact sheets, documents, publications. Links are provided to various fact sheets, such as the multiagency fact sheet on *P. piscicida* and the fish lesion fact sheet.

State Outreach and Communication Programs

Most of the coastal states where *Pfiesteria* has been detected have compiled outreach and educational programs to address the many queries they have received, mainly from the general public. The extent of these outreach efforts varies significantly from state to state on the basis of funding and the public's perception of the *Pfiesteria* problem in that state. For comparison, the efforts of two states are summarized below.

New York

This state has only recently begun a *Pfiesteria* monitoring program and thus their outreach program is in its early stages. Three state agencies have joined together to prepare a fact sheet on *P. piscicida* in New York State, which is distributed to requestors along with a cover letter from the state health officials. The fact sheet explains that although *Pfiesteria* has been detected in New York waters, it has not caused any toxic outbreaks or fish kills there. Also included in the fact sheet is a map of the New York coastline indicating where 1998 sampling was done and where *Pfiesteria* was detected (10).

South Carolina

In 1997 the South Carolina Task Group on Harmful Algae was formed and charged with developing a coordinated state strategy to respond to possible *Pfiesteria*-related and other HAB events (11). The task force includes members from South Carolina Sea Grant Consortium, the South Carolina Department of Health and Environmental Control, the South Carolina Department of Natural Resources, and several university representatives. The group has established monitoring and fish event response programs, a human health surveillance program, and a public information and outreach program to increase the awareness of the issue among resource managers, community officials, coastal users, and the general public. As part of the outreach component, South Carolina circulated a *Pfiesteria* facts sheet throughout the state and followed up with a newsletter that is published twice a year. In addition, task force members make an effort to talk to numerous public and professional groups such as fishermen societies,

Sierra Club, and the League of Women Voters, as well as various school groups. New funding to the program will allow expansion of their outreach program. Plans include increasing publication frequency and distribution of the newsletter; establishing a website specifically for the South Carolina Task Group on Harmful Algae; distributing the "Sourcebook for Teaching about Harmful Algal Blooms (HABs)" to high schools and middle schools; and providing inservice training for county extension agents, who in turn will channel this information to the general public. Another initiative is the establishment of the South Carolina Phytoplankton Monitoring Network, which involves the participation of high school student volunteers to determine the distribution of HABs statewide. This program will be based on a similar, highly successful program in Maine.

Fact Sheets

Multiagency *Pfiesteria* Fact Sheet

This flyer is geared toward the general public and provides information about *Pfiesteria*, toxic outbreaks, location of problems, human health problems, seafood safety, and state hotlines (12). This fact sheet is available on several websites (e.g., <http://www.redtide.who.edu/pfiesteria/> and <http://www.epa.gov/OWOW/estuaries/pfiesteria/index.html>). Plans are under way, through the U.S. EPA and the PIC Workgroup, to provide an updated, condensed version of the flyer for wide distribution.

What You Should Know about Fish Lesions

This flyer was developed and edited by a subset of the PIC Workgroup, and published by the U.S. EPA in 1999, with endorsements by NOAA, USGS, CDC, and all 12 coastal states involved in *Pfiesteria* monitoring (13). The flyer is geared toward the general public and provides background information on fish kills and fish lesions and describes what to do and what not to do if you see fish with lesions or see fish behaving strangely. It also provides several related website addresses and state hotlines to report such occurrences or human health problems. This document was distributed to each of the federal agencies and states involved and is also available (PDF format) on several of the websites mentioned above (e.g., <http://www.redtide.who.edu/pfiesteria/> and <http://www.epa.gov/OWOW/estuaries/pfiesteria/index.html>).

Training Manuals and Documentaries

"Harmful Microalgae and Associated Public Health Risks in the Gulf of Mexico"

This training manual, prepared by K.A. Steidinger and H.L. Melton Penta, is available

from the Gulf of Mexico Program Office (hard copy) or from the following website (PDF format): <http://www.fmri.usf.edu/redtide/pubs/manual/toc.htm>. The manual was produced for use by resource personnel investigating harmful algal blooms and by regulatory personnel making management decisions. An accompanying video with the same title complements the manual. Along with information on other harmful microalgae found in the Gulf of Mexico, this manual includes information on *Pfiesteria* and *Pfiesteria*-like species. For each species, information is provided on its distribution, habitat, toxins, associated impacts, and what is known and not known about the organism (14).

The manual also includes a useful section on the procedure for collecting and shipping sediment and water samples containing *Pfiesteria* and *Pfiesteria*-like species.

"Nature Out of Balance"

This two-part documentary film produced by the University of North Carolina television I.Q. series, is available from the North Carolina Sea Grant office (website: http://www2.ncsu.edu/sea_grant/seagrant.html). The documentary addresses questions posed by the general public and policy makers. The first part defines HABs and what is known about health risks, toxins, current research, and economic impacts. Some information is also included on *Pfiesteria* and related human health risks and current research initiatives on the organisms. The second part provides more information about *Pfiesteria*: human health advisories from physicians and North Carolina officials; symptoms of stressed river health; water quality monitoring programs; and medical links between water quality and human health.

"Algae: A Sourcebook for Teaching about Harmful Algal Blooms"

This teacher's guide has just been published and contains background information on algae and HABs, educational resources, and classroom lessons and activities (15). Major sections include collecting equipment and techniques, culturing algae, modeling algal blooms, mapping harmful algal blooms, and tracing the movement of algal toxins in the food chain.

"Field Guide for Describing External Fish Lesions"

This guide is currently under development by Andrew Kane at the University of Maryland. It will provide a uniform systematic fish health assessment procedure accompanied by photos and text illustrating and describing gross fish pathology, including different grades or levels of external fish lesions. The field guide will standardize field assessment procedures among the states and research institutions and will provide uniform illustrations to accurately

describe field observations regarding the type and severity of external fish lesions. Although the field guide is currently under construction, it may be accessed at the following URL: <http://aquaticpath.umd.edu/lesionguide>.

Summary

There is a wealth of information available on the Internet regarding *Pfiesteria* and *Pfiesteria*-like organisms, but it is scattered among many different sources. We hope this summary will make it easier to access these resources. As individual websites are further modified or created, site managers should include information on HABs in general, or links to other sites with such information. We feel it is of great benefit to link *Pfiesteria* to the U.S. National HAB program rather than to focus exclusively on one group of organisms. Training and outreach programs should incorporate this thinking as well. This should help to place the public's perception of the *Pfiesteria* problem in the proper context and avoid some of the overreactions and hysteria of the past.

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